ГЕОЛОГІЯ

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ON RAW MATERIALS OF NEOLITHIC STONE HOES FROM THE DNIEPER RAPIDS AREA

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ПРО СИРОВИНУ НЕОЛІТИЧНИХ КАМ'ЯНИХ МОТИК З ДНІПРОВСЬКОГО НАДПОРІЖЖЯ

Purpose. To determine the types and origins of rocks used in the Dnieper Rapids Area during the Neolithic Age (7^{th}–5^{th} millennia BCE) for making of artifacts identified as hoes in the collection of Dnipropetrovsk National Historical Museum named after D. I. Yavornytskyi. To determine specialties of usage of the raw materials by ancient craftsmen for making stone hoes.

Methodology. Petrographic analysis of the stone hoes from the museum's collection. Sampling of outcrops in the area where the artifacts were found and petrographic analysis of the sampled specimens. Use of logical analogy in comparing the artifacts raw materials with the rocks of the Dnieper valley to determine the probable origins of the raw materials.

Findings. It was determined that during the Neolithic Age the following local rocks were used by the population of the Dnieper Rapids Area to make stone hoes: trondhjemite, tonalite, granodiorite, diorite, granite, amphibolite, migmatite, vein quartz and epidosite. The raw materials of practically all stone hoes of the known origin (Ihren peninsula) were mined at nearby outcrops of the Dnipropetrovskyi and Surskyi granitoid complexes. Use of almost all local rock types bears evidence to the fact that there were no strict requirements for properties of the raw materials. Use of local granitoids and concomitant rocks for making stone hoes can be explained by relict layered structure of the rocks which made it easier to detach plates of desired shape. Results of the study show that during the Neolithic Age active use of the Middle Dnieper Area rocks began along with the emergence of primitive mining.

Originality. For the first time Neolithic stone hoes from the Dnieper Rapids Area were studied by means of petrographic analysis in thin sections and the stone hoes raw materials were compared with rocks of the area using the results of the analysis.

Practical value. The findings can be used in reconstructing the history of the beginning of mining in the Middle Dnieper Area.

Keywords: *ancient mining, Neolithic Age, Dnieper Rapids Area, granitoids, stone hoes*

Introduction. The Dnieper Rapids Area, which is located in the valley of the river Dnieper in the zone of the Dnieper rapids (submerged in 1932) and surrounding territory, is rich in Neolithic archeological sites. The Neolithic Age in the Middle Dnieper Area dates back to the 7^{th}–5^{th} millennium BCE [1]. This historical period is connected to the rise of agriculture that demanded new types of tools, most of which were made of stone materials. It promoted the development of mining, firstly, to meet the need for raw stone. The main stone material of that time was flint, which was extracted using mining methods. The Dnieper Rapids Area has no deposits of this raw material; therefore, flint was delivered to the Dnieper Valley from other regions. Meanwhile, the Neolithic Age is characterized as a time when the active use of other stone materials began, particularly those widespread in this territory. Previous research of talc rock usage in the Dnieper Rapids Area led us to draw a conclusion about the only centre of their mining [2]. Also, petrographic analyses of selected Neolithic tools from the Middle Dnieper Area proves the usage of local rocks for the production of stone axes, hammers, grindstones, grain grinders, etc. [2].

Flat rounded artifacts identified as hoes that were found throughout the Area are located in the collection of such items of Dnipropetrovsk National Historical Museum named after D.I.Yavornytskyi. It should be noted that the origin of most of these tools is unknown; however, some were found on the Ihren peninsula, which is situated within the borders of the city of Dnipropetrovsk on the left bank of the river Dnieper near the place where the river Samara flows into it. Here, during several millennia, settlements of Neolithic cultures existed, particularly Surska (7th–5th millennium BCE) and Dnipro-Donetska (7th–4th millennium BCE) cultures [1].

Research of such widespread tools as stone hoes permits adding some new data to the already existing information on the usage of the Middle Dnieper Area rocks, which will make it possible to complete the first summarized list of rocks used by the local population in the Neolithic Age.

Analysis of the recent research. A part of the stone hoes collection was earlier studied macroscopically by Viktor Petrun, who, according to records in the card file, had done a general determination of the hoes raw materials and established that they were local and descended from the Ukrainian Shield. Though, in the descriptions of some artifacts the researcher mentioned the necessity of thin section petrographic examination. In general, there have been no publications devoted to petrographic research of this type of tool of the Middle Dnieper Area.

Unsolved aspects of the problem. Until now there have been no studies of the Neolithic stone hoes using a polarizing microscope. Determination of their raw material and its origin was made on the basis of macroscopic observation only. Because of the lack of necessary studies, it is impossible to determine the list of rocks which were used for the production of this type of tool, as well as to compare them with similar rocks of the Ukrainian Shield to confirm their local origin and to define more exactly the places of their extraction.

Objectives. The purpose of the research is to determine the names, origins and usage characteristics of the rocks which were used as raw material for the production of stone hoes in the Dnieper Rapids Area during the Neolithic Age. To achieve the purpose it was necessary to perform petrographic studies of the ancient goods collection; to collect specimens in the outcrops located near the places where artifacts were found and to carry out petrographic analysis on them, as well as to compare the results of petrographic studies with the data of geological reports and the literature on the petrology of the region.

Presentation of the main research and explanation of scientific results. To carry out the research we were given access to the collection of 27 items (Table) which are stored in Dnipropetrovsk National Historical Museum named after D.I.Yavornytskyi. The hoes appear as flat, mainly rounded, sometimes oblong, roughly cut tools (Fig. 1).

The hoes were made of hard rocks from light grey to almost black in colour. Those made of granitoid rocks often had a banded (gneissoid) structure and therefore they can be classified as gneissose granites. Some artifacts were made of two rocks in contact with a gradual or sharp transition between them. Possibly, this is related to the origin of these raw materials from migmatite complexes.

Obtaining thin sections from small and undamaged artifacts in museum collections is usually impossible because a quantity of material must be cut off, thus damaging the object. On the other hand, the application of polarized light microscopy is essential, because the composition and origin of rocks belonging to granitoid complexes, from which the raw materials of the tools originate, can be determined precisely only by this method. In order to minimize the damage of artifacts we used a portable stone cutting machine, which can saw off stone plates as thin as 1–2 mm. Since the tools were roughly made, the cutting of imperfections protruding from the surface or of fragments from damaged parts did not cause harm to the general appearance of artifacts. Thin sections were made from the obtained plates. As a result of their study the raw material of each item was determined.

Petrographic analysis of the thin sections showed that the following rocks were used as raw materials for the Neolithic stone hoes: trondhjemites, tonalites, granodiorites, diorites, granites, amphibolites, migmatites, vein quartz and epidosites.

Trondhjemites make up the largest group among the examined samples (1, 2, 4, 6, 17, 18, 22, 23, 27) and have similar mineral composition. The main minerals of the

Fig. 1. Hoe of ellipsoidal rounded shape (sample 3)

rocks are plagioclase, quartz and biotite (Fig. 2). Plagioclase composes from 45 % (sample 1) to 75 % (sample 6) of the rocks, while quartz composes from 25 to 35 %. Biotite is contained in about 5 volume per cent in the majority of samples. Increased content of this mineral (up to 7–10 %) was found in samples 2, 23 and 27.

Muscovite, microcline and opaques are present as minor minerals. Muscovite was found in samples 1 and 27, in quantities of 2 % and less than 1 % respectively; microcline is contained in samples 2 and 18 (5 % and 3 % respectively). Opaque minerals compose up to 1 % of the rocks. Secondary minerals are represented by epidote, chlorite and sericite; accessory minerals are apatite and zircon.

Trondhjemite of sample 1 is altered by retrogressive metamorphism. Plagioclase is sericitized, and biotite is replaced by chlorite-epidote aggregate, with 5 % of chlorite and 3 % of epidote content in the rock. Chlorite also forms thin veins and individual grains. In addition to that, products of oxidation were found in the

Table

Studied artifacts

№	Description (according to the museum card file)	Measurements, cm	Place of origin	Raw material
1	Ellipsoidal hoe with one pointed end	17x12.5		Trondhjemite, retrogressively metamorphized
2	Subellipsoidal rounded hoe	12.3x10.4		Biotite trondhjemite
3	Subellipsoidal rounded hoe	12.6x10.8		Diorite, epidotized
4	Stone hoe	10.34x7.7x2		Biotite trondhjemite
5	Stone hoe	14x9.6x3.3		Granite, leucocratic (pegmatoid)
6	Riven stone hoe	12.1x8.25x1.9		Biotite trondhjemite, aplitoid (leucosome of migmatite)
7	Stone hoe	8.75x7,55x1.6		Migmatite – transition between leucosome (trondhjemite) and melanosome (leucocratic amphibolite)
8	Stone hoe	11.6x8.4x2.75		Tonalite, altered
9	Stone hoe	8.2x10.3x1.7		Migmatite (inclusions of melanosome into leucosome)
10	Stone hoe	9.6x6.3x0.98		Epidosite (altered trondhjemite or plagiogneiss)
11	Oblong stone hoe	10x8.5	Ihren-8, burial ground	Diorite, altered
12	Riven stone hoe (semicircular)	12.1x6.05x1.25		Amphibolite
13	Stone hoe	9.5x7.1x4.2		Biotite-hornblende tonalite
14	Stone hoe	d (max) – 8.35 thick. – 2.1		Biotite-hornblende diorite
15	Stone hoe	9.7x7.5x2.4		Vein quartz
16	Stone hoe	d (max) – 9 thick. – 2.1		Granite, biotitic
17	Stone hoe	d (max) – 9.45 thick. – 2.3	Ihren (?)	Biotite trondhjemite
18	Stone hoe	10.7x11.1x2.3		Trondhjemite, leucocratic, aplitoid
19	Stone hoe	d (max) – 8.5 thick. – 2.4		Vein quartz
20	Wedge-shaped stone hoe	7.85x8.5x1.5	Ihren peninsula	Contact of amphibolite and trondhjemite (vein in migmatite)
21	Wedge-shaped discoid stone hoe	11x8.6x2	Ihren peninsula	Tonalite, cataclased, with an epidote vein
22	Stone hoe. Wedge-shaped disc with a dull back	7.5x8.6x2.1	Ihren peninsula	Biotite trondhjemite
23	Stone hoe. Discoid suboval shape	8.4x4.8x2.2	Ihren peninsula	Trondhjemite with gneissoid structure
24	Stone hoe. Polyhedral wedge	10x9.4x2.9	Ihren peninsula	Amphibolite
25	Stone hoe. Disc with acute ribs	10.7x7.4x 2.7	Ihren peninsula	Granodiorite, biotitic (gneissose)
26	Stone hoe. Subtriangular disc	10.4x10.3x1.9	Ihren peninsula	Biotite tonalite
27	Stone hoe. Subtriangular wedge	8.5x7.3x2.5	Ihren peninsula	Biotite trondhjemite

form of particulate goethite. The rock has relict hypidiomorphic-granular (granitic) texture.

The rest of the samples are much less altered. Plagioclase of sample 17 is slightly saussuritized; in other samples it is partially sericitized and epidotized. Biotite of sample 17 is fractionally replaced by chlorite.

In regard to the textures, the rocks split into two groups: hypidiomorphic-granular texture (samples 2, 4, 22, 23) and allotriomorphic-granular texture (samples 6, 17, 18, 27). In the latter group of samples plagioclase crystals are sometimes euhedral. Some plagioclase crystals of sample 4 have prismatic shape and show twinning under crossed nicols. Quartz grains in the rocks are usually anhedral. In sample 18, which differs from others by being leucocratic (biotite content is less than 1 %), quartz is granulated. Sometimes the gneissic structure manifests itself on a microscopic scale with sub-parallel orientation of biotite scales.

Tonalites compose four artifacts (8, 13, 21 and 26). There is a little distinction between rocks of different samples. The minerals of sample 8 are altered by chloritization and epidotization. Sample 13 belongs to the biotite-hornblende variety of tonalite, while sample 26 belongs to the biotite variety. The tonalite of sample 21 is partly cataclastic and altered in the same way as the rock of sample 8.

Plagioclase composes 65 % to 74 % of rocks in the samples studied; the mineral is mainly represented by andesine. Quartz content is from 17 % to 19 % of the rock volume. Biotite takes up to 10 % in samples 8, 21 and 26. In sample 2 the mineral is contained in the amount of 2 % only, and 5 % is composed of hornblende. Epidote is present in all samples in a quantity of 1–2 %. Biotite is chloritized to a different degree, except for sample 26. Plagioclase of the raw material of artifacts 13 and 29 is slightly and moderately sericitized. Apatite is an accessory mineral of the tonalite. Plagioclase usually forms idiomorphic tabular grains; quartz and biotite are anhedral.

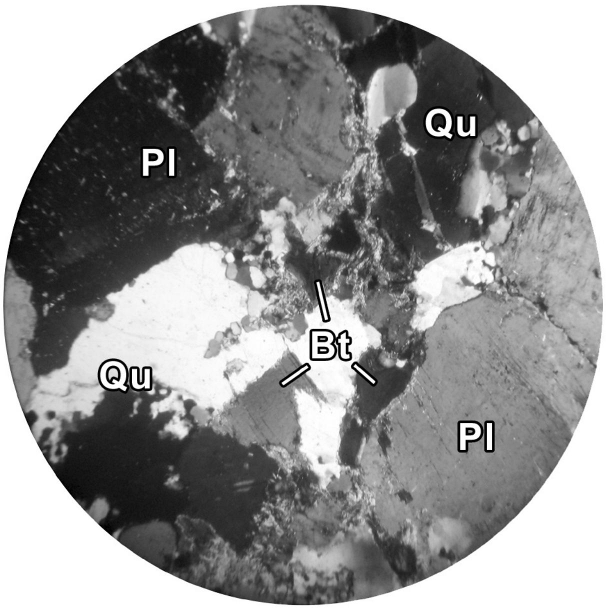

Fig. 2. Biotite trondhjemite (sample 2):
Pl – plagioclase; Qu – quartz; Bt – biotite.
Thin section, crossed nicols, field of view – 2.8 mm

The textures of the rocks are different. Allotriomorphic-granular texture was identified in thin sections of samples 8 and 13, while samples 21 and 26 featured hypidiomorphic-granular texture. Cataclasis areas with epidote crystals were observed in sample 21's thin section.

Diorites are represented by three samples in the collection studied (3, 11, 14). Rocks of samples 3 and 14 belong to the biotite-hornblende variety (Fig. 3); sample 11 does not contain biotite in the thin section. Major minerals of the rocks are plagioclase (60–70 %) which was identified as oligoclase-andesine, and hornblende (25–35 %). Biotite is contained in an amount of 5 % in samples 3 and 14. Besides, single grains of microcline and quartz were found in sample 14. Opaque minerals compose up to 1 % of the rock volume, wherein it is magnetite in samples 11 and 14, and pyrite in sample 3. Accessory apatite is present in samples 3 and 14; in the former case the mineral forms single grains, in the latter case its content is up to 1%.

Rocks of all three samples contain secondary minerals and are altered. Epidote replaces plagioclase and hornblende. Sample 3 is the most epidotized, with epidote aggregates forming pseudomorphs after hornblende crystals. In sample 14 epidote replaces plagioclase alone and amounts to less than 1 %. Biotite is significantly chloritized in samples 3 and 14. Moreover, sericite replaces plagioclase to various degrees in all samples. The plagioclase of sample 3 is the most sericitized.

Rocks of samples 11 and 14 show hypidiomorphic-granular texture. The significantly altered diorite of sample 3 has relict allotriomorphic-granular texture, but since the rock consists mostly of metamorphic minerals its texture can be identified as lepido-granoblastic.

Amphibolites are the raw materials of three artifacts (12, 20 and 24). Sample 20 is composed of amphibolite and trondhjemite.

Hornblende and plagioclase are major minerals of all amphibolites studied. The highest content of hornblende (up to 75 %) is found in sample 12; in the rest of the samples the mineral makes up a little more than 50 % of the rock volume. Single grains of quartz are present in the amphibolite part of sample 20 which probably is due to contact with granite. As a minor mineral epidote replacing hornblende is present in an amount of 2–3 % in sample 12. An accessory mineral in sample 24 is apatite; secondary minerals are sericite (after plagioclase) and goethite. In the thin section of sample 12 single aggregates of opaque mineral were observed. All amphibolites have granoblastic texture with uneven distribution of mineral grains (glomero-granoblastic texture). The mineral composition of the granite part of sample 20 includes saussuritized plagioclase, quartz, biotite and goethite. Textures of this part are hypidiomorphic-granular and porphyritic.

Granites were found in two samples of the collection studied (5 and 16). The rocks have some differences. For example, sample 5 is composed mainly of plagioclase, which constitutes 50 % of the rock, while the amount of potassium feldspar (microcline) is only 24 %. There are many perthites and antiperthites in the rock. Quartz content is 25 % of the rock volume, opaque minerals amount to 1 %, and goethite admixture is also present. Dark-coloured minerals are absent in the thin section. Plagioclase is insignificantly replaced by secondary minerals, namely sericite, and microcline is slightly to moderately replaced by clay minerals. The rock texture is hypidiomorphic-granular.

Sample 16 differs from the previous one by predominance of potassium feldspar over plagioclase. Microcline makes up 55–60 % of the rock volume, while plagioclase accounts for no more than 15 % and quartz for 25 %. Biotite is partially replaced by chlorite, and both minerals amount up to 2 %. Oxidized opaque mineral accounts for less than 1 %. Secondary sericite fractionally replaces feldspars. The rock texture is allotriomorphic, medium-grained. Crystals of potassium feldspar usually have a larger size compared to other minerals and are more idiomorphic in shape.

Two samples of the collection studied (7, 9) were identified as *migmatites* considering that the rocks are composed of light-coloured and dark-coloured parts (leucosome and melanosome).

Sample 7 represents a gradual change from leucosome of trondhjemite composition to melanosome of leucocratic amphibolite composition. The light granitic mass contains segregations of dark-coloured minerals; the concentration of those gradually increases until the rock becomes dark-coloured. A thin section contains a gradual transition from one part of the rock to another. Mineral composition of the migmatite is: plagioclase feldspar, quartz, biotite, hornblende and 1 % of microcline. Biotite and hornblende form segregations. Single scales of biotite are also present in the granitic part. Plagioclase crystals exhibit a tabular habit; the mineral is partially sericitized. Quartz forms aggregates of fine granular grains. Considering the probable metamorphic genesis of the rock, its texture was defined as glomero-lepidogranoblastic.

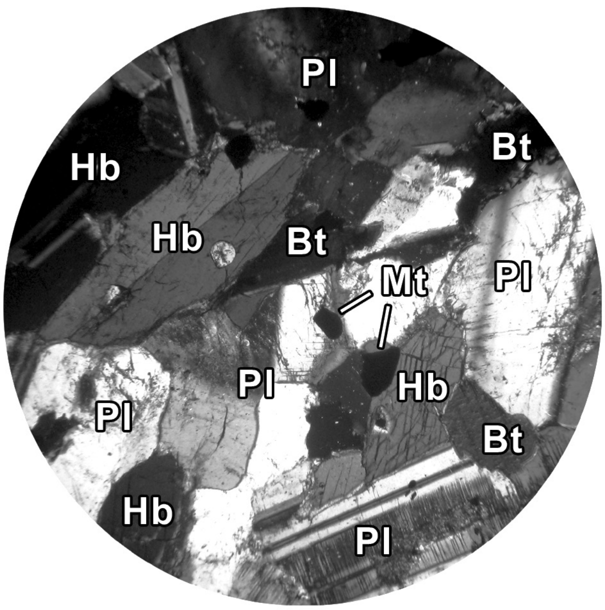

Fig. 3. Biotite-hornblende diorite (*sample 14*):

Pl — plagioclase; Hb — hornblende; Bt — biotite; Mt — magnetite.
Thin section, crossed nicols, field of view — 2.8 mm

Sample 9 features segregations of melanosome in the form of small patches. The thin section was made from a contact of the two parts of the migmatite. The mineral composition of the leucosome is plagioclase feldspar, quartz and about 1 % microcline, which corresponds to trondhjemite. Plagioclase is sericitized, quartz forms aggregates of fine granulated grains between coarse grains of feldspar. Melanosome is composed of altered hornblende, plagioclase, biotite and chlorite (after hornblende and biotite). Thin veins of epidote are also present in the rock. Mineral composition of the melanosome corresponds to biotite amphibolite. As a whole, the migmatite texture can be identified as heteroblastic. Considering presence of dark-coloured patches in granite mass the rock structure is defined as schlieren.

Vein quartz. Two of the tools (samples 15 and 19) were crafted out of essentially quartzose mineral aggregate which, we suppose, came from quartz veins. The rock consists of granular aggregate of large grains with wavy extinction and fine granulated ones. Besides quartz, single grains of opaque minerals and impurity of brown goethite were present in the thin sections.

Granodiorite was identified as the raw material of one of the artifacts (sample 25). The rock differs from the tonalites described above by the presence of microcline amounting to about 7 %. Quartz composes 20 % of the rock. Dark-coloured minerals are represented by biotite with 5 % content. Secondary epidote replaces feldspar; accessory magnetite forms euhedral crystals. Both minerals make up to 1 % of the rock, the rest of which is composed of plagioclase. The granodiorite texture is allotriomorphic-granular. The rock structure is gneissic which on a microscopic scale results in an oriented arrangement of biotite flakes.

One of the artifacts was made of *epidosite* (sample 10), which probably was formed after trondhjemite or biotite plagiogneiss. The mineral composition of the rock is: 55 % epidote, 25 % quartz, 10 % plagioclase and 10 % biotite (chloritized). Plagioclase is insignificantly replaced by sericite. Chloritized biotite scales are oriented sub-parallel. The rock was exposed to cataclase; its texture was identified as lepido-granoblastic and cataclastic.

Origins of the artifacts raw materials. While determining origins of the rocks, apart from literary sources we used the materials of the Geological Survey of the area (O. D. Timoshenko et al., 1962; A. A. Zaitsev et al., 1963) which give the most complete information on natural outcrops of rocks that could be used during ancient times.

All the aforementioned rocks used for making stone hoes are characteristic of the Dnieper Rapids Area. There are numerous outcrops of granitoids of different composition here, along the river Dnieper and its tributaries. The main feature of these rocks in the Serednioprydniprovskyi (Middle Dnieper) megablock of the

Ukrainian Shield is a predominance of plagioclase varieties which is also seen in the artifacts raw materials. Granitoids of the Dnipropetrovskyi Paleoarchean complex are the most common in the area. Generally, they present alternation of strata that consist of gneissose tonalite and trondhjemite rocks along with granodiorites and two-feldspar granites. Besides, the complex includes veins of leucocratic plagiogranites and pink aplite-pegmatite granites [3]. Sediments of the Aulska series, the oldest stratigraphic unit in the Dnieper Rapids Area, are included in the Dnipropetrovskyi complex as well. As a result of ultrametamorphism they transformed into granitic gneisses and migmatites which are present among granitiods of the Dnipropetrovskyi complex in the form of relicts [4]. According to the Geological Survey reports gneisses, amphibolites, crystalline schists and other rocks appear as parts of migmatites in numerous outcrops. Granitoids of the younger Surskyi complex (Mezoarchean Age) are similar to the rocks of the Dnipropetrovskyi complex and are represented by intrusive trondhjemite, tonalite, granodiorite, etc. [4]. Surskyi complex granitoids often contain xenoliths of the Dnipropetrovskyi complex plagiomigmatites [3]. The epidotizaton process is very characteristic of granitoids of the area. We studied epidote veins within Dniepropetrovsk on the right bank of the river Dnieper (in Shevchenko Park), at the Ihren peninsula, in Stari Kodaky village, at the mouth of the river Mokra Sura which flows into the river Dnieper downstream from Dniepropetrovsk in Voloske village and at other sites. Thus, epidosite similar to the one of sample 10 can be found in the area as well. Quartz veins are also common in the granitoids; for instance, they are spread at the Rybalske deposit near the Ihren peninsula. Such rock could be used as the raw material of samples 15 and 19.

In this way raw materials of all the studied stone hoes have analogues among the rocks common to the Dnieper Rapids Area and are most likely of the local origin.

A more precise determination of the raw material origins requires knowledge of the places of artifacts findings. The exact location is known only for the stone hoes found at the Ihren peninsula on the river Dnieper left bank. According to the valid Correlation Chronostratigraphic Chart of the early Precambrian Age of the Ukrainian Shield, the granitoids of the Ihren peninsula belong to the Surskyi complex [4]. Nowadays there are natural outcrops of granitoids in the form of low rounded promontories near the location of ancient settlements (Fig. 4). Besides, a passage was made in the rock massif for railway construction in the middle of the last century whereupon artificial outcrops appeared.

Since relief and rock outcrops could change during several millennia, we sampled outcrops of the rock types from the entire territory and performed their petrographic study to obtain the most complete picture. We determined the following rocks as being identical to the raw materials of the hoes: biotite and leucocratic trondhjemite, tonalite, granodiorite, diorite, amphibolite, aplite-pegmatite granites and epidosite.

Trondhjemites from natural outcrops are similar to the raw materials of samples 2, 4, 6, 17, 22, 23 and 27 (Fig. 5). Plagioclase composes 60–65 %, quartz makes 25–30 % and biotite makes 5–7 % of the rocks. Opaque minerals are present in small amounts, about 1 %. Single scales of muscovite also occur in the rocks. Just like in the artifacts raw materials, secondary minerals are represented by epidote and chlorite; plagioclase is moderately sericitized. The rock texture is hypidiomorphic-granular. Biotite trondhjemite with gneissoid structure (sample 23) shows similarity on textural features to the quartz-rich trondhjemite found at an outcrop at the Ihren peninsula.

The leucocratic aplite-like trondhjemite of sample 21 also has its analogue among the rocks of the outcrops. Similar rock is found as a leucosome of migmatites in which, as well as in sample 21, plagioclase content is 70 % and quartz 30 %; biotite and epidote together compose less than one per cent of the rock. Plagioclase is slightly sericitized. Another similarity is that quartz is granulated in both samples.

Tonalites exposed in the Ihren peninsula's artificial outcrops have vague banding due to quartz and hornblende change which results in transforming the rock into diorite. The latter rock is identical to the biotite-hornblende diorite of sample 14. The rocks show similarity in mineral composition, texture and structure. Plagioclase composes 70 %, hornblende 26 %, biotite 3% and magnetite 1 % of the rock from the outcrop. There is a little difference in secondary sericite content. The structure of both rocks is hypidiomorphic-granular.

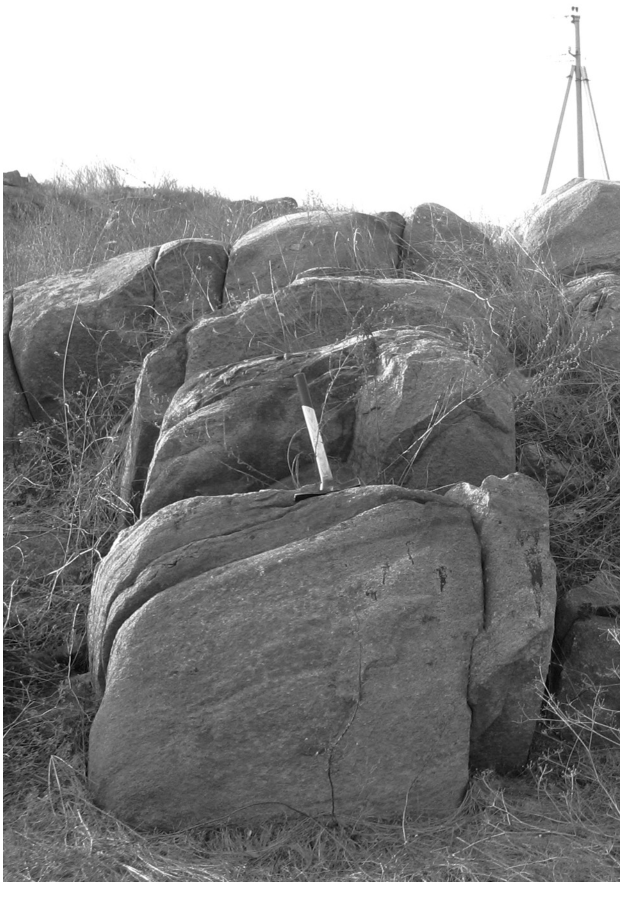

Fig. 4. Outcrops of granitoids at the Ihren peninsula

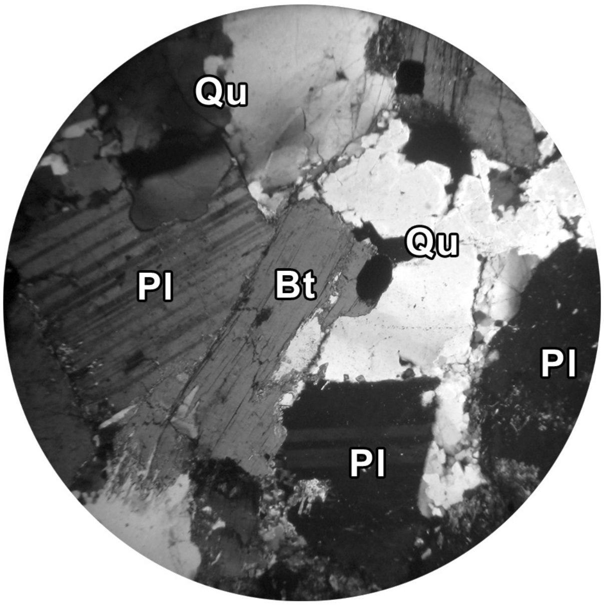

Fig. 5. Biotite trondhjemite (the Ihren peninsula): Pl – plagioclase; Qu – quartz; Bt – biotite. Thin section, crossed nicols, field of view – 2.8 mm

Raw materials of the amphibolite tools (samples 12, 20, 24) have their analogue among rocks of the outcrops as well. For instance, amphibolite being similar to one of the artifacts is exposed at natural outcrops as part of migmatite. There are also large amphibolite packs with aplite-like granite veins in the artificial outcrop. The rocks are composed of green hornblende, plagioclase and secondary epidote; they contain single aggregates of opaque mineral as well. The Ihren amphibolite has a lower amount of hornblende compared to the rock of sample 12. The amphibolite texture is glomero-granoblastic.

Thus, raw materials of the majority of the stone hoes discovered at the Ihren peninsula have their analogues among rocks exposed today near the location of ancient settlements and burial grounds. As for the tool made of granodiorite, this rock is not exposed nowadays, but can be found in the area. Such rock is present at the southern part of the Rybalske deposit located nearby. It could also originate from other local outcrops such as the ones on the right bank of the river Dnieper.

Conclusions. As a result of petrographic analysis it has been proved that in the Neolithic Age in the 7th–5th millennium BCE the first agriculturists of the Dnieper Rapids Area used local rocks of the Dnipropetrovskyi and Surskyi granitoid complexes for the production of hoes, most probably because the layered structure of the rocks due to relic gneissic structure facilitated mining. Amphibolites, veins of leucogranites, quartz and epidote also forme flat bodies inside migmatites, which occur in the outcrops along with granitoids. In the outcrops of weathered rocks similar to the observed ones on the Ihren peninsula, the rocks flake into plates of different composition. Ancient craftsmen could easily separate plates of desired shape and then, using raw processing, make tools with desired characteristics. To produce hoes almost all the local rocks listed were used: granites, trondhjemites, tonalites, diorites, granodiorites, epidosites, and vein quartz. These rocks have different mechanical properties including hardness, abrasiveness, etc. Therefore, the conclusion can be drawn that there were no strict requirements for properties of rocks used as raw materials for stone hoes, in contrast to the strict requirements for talc atlatl stone weights or plates. Thus, to produce stone hoes, hard layered rocks from nearby outcrops were used, as the materials originating from the Ihren peninsula show.

The results obtained supplement existing evidence of the beginning of active use of the Middle Dnieper Area rocks in the Neolithic Age with the advent of primitive mining. The local population that lived in the valley of the river Dnieper accomplished organized mining of talc rocks for atlatl weighs and plates production; they used dolerite, amphibolite, sandstone, granite, quartzite and limestone for production of polished weapons and tools; they mined sandstones, granites and tremolite-chlorite slates for abrasive stones and grain grinders production; and they carried out systematic extraction of the aforementioned rocks of the granitoid complexes to produce primitive stone hoes.

Further petrographic studies may broaden our knowledge about the usage of the Middle Dnieper Area rocks in the Neolithic Age.

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Нікітенко І. С. Дослідження сировини кам'яних виробів періоду неоліту-бронзи з колекції Дніпропетровського національного історичного музею ім. Д. І. Яворницького / І. С. Нікітенко, М. Л. Куцевол // Збірник наукових праць Національного гірничого університету. – Дніпропетровськ: ДВНЗ „НГУ", 2012. – №38. – С. 11–19.

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Кореляційна хроностратиграфічна схема раннього докембрію Українського щита (пояснювальна записка) / [Єсипчук К. Ю., Бобров О. Б., Степанюк Л. М. та ін.]. – К.: УкрДГРІ, 2004. – 30 с.

Мета. Визначити найменування та походження гірських порід, які використовувалися у Дніпровському Надпоріжжі за доби неоліту (VII–V тис. до н. е.) для виготовлення знарядь, що значаться у фондах Дніпропетровського національного історичного музею ім. Д. І. Яворницького як мотики. Встановити особливості використання кам'яної сировини для виготовлення мотик стародавніми майстрами.

Методика. Сировину знарядь було досліджено за допомогою петрографічного аналізу. Проведено відбір зразків гірських порід з відслонень району знахідки артефактів та петрографічне дослідження цих зразків. При порівнянні матеріалу артефактів з гірськими породами долини р. Дніпро для з'ясування походження сировини виробів була застосована логічна аналогія.

Результати. Було доведено, що за доби неоліту для виготовлення кам'яних мотик населенням Дніпровського Надпоріжжя використовувалися місцеві гірські породи дніпропетровського та сурського гранітоїдних комплексів: трондьєміти, тоналіти, діорити, двопольовошпатові граніти, амфіболіти, мігматити, жильний кварц, гранодіорити та епідозити. Сировина практично всіх кам'яних мотик, що мають відоме походження (Ігренський півострів), була видобута на найближчих відслоненнях гранітоїдів. Використання майже повного переліку місцевих порід свідчить про те, що особливих вимог до властивостей матеріалу мотик не висувалося. Застосування місцевих гранітоїдів та супутніх їм порід для виготовлення мотик може пояснюватись їх реліктовою шаруватою будовою, що полегшувало відділення пластин потрібної форми. Отримані результати свідчать на користь того, що за доби неоліту розпочалося активне використання гірських порід Середнього Придніпров'я із виникненням примітивного гірництва.

Наукова новизна. Уперше були досліджені неолітичні кам'яні мотики з Дніпровського Надпоріжжя за допомогою петрографічного аналізу у шліфах. Уперше порівняна сировина кам'яних мотик з гірськими породами району на основі мікроскопічного дослідження.

Практична значимість. Отримані дані можуть бути використані при реконструкції історії зародження гірничої справи на території Середнього Придніпров'я.

Ключові слова: *стародавнє гірництво, неоліт, Дніпровське Надпоріжжя, гранітоїди, кам'яні мотики*

Цель. Определить наименование и происхождение горных пород, использовавшихся в Днепровском Надпорожье в эпоху неолита (VII–V тыс. до н. э.) для изготовления орудий, которые значатся в фондах Днепропетровского национального исторического музея им. Д. И. Яворницкого как мотыги. Установить особенности использования каменного сырья для изготовления мотыг древними мастерами.

Методика. Сырье орудий было исследовано при помощи петрографического анализа. Проведен отбор образцов горных пород с природных обнажений района находки артефактов и петрографическое изучение этих образцов. При сравнении материала артефактов с горными породами долины р. Днепр для выяснения происхождения сырья изделий была применена логическая аналогия.

Результаты. Было доказано, что в эпоху неолита для изготовления каменных мотыг населением Днепровского Надпорожья использовались местные горные породы днепропетровского и сурского гранитоидных комплексов: трондьемиты, тоналиты, диориты, двуполевошпатовые граниты, амфиболиты, мигматиты, жильный кварц, гранодиориты и эпидозиты. Сырье практически всех каменных мотыг, имеющих известное происхождение (Игренский полуостров), было добыто на ближайших обнажениях гранитоидов. Использование практически полного перечня местных пород свидетельствует о том, что к свойствам материала мотыг особые требования не предъявлялись. Применение местных гранитоидов и сопутствующих им пород для изготовления мотыг может объясняться их реликтовым слоистым строением, что облегчало отделение пластин необходимой формы. Полученные результаты свидетельствуют в пользу того, что в эпоху неолита началось активное использование горных пород Среднего Приднепровья с возникновением примитивного горного дела.

Научная новизна. Впервые были исследованы неолитические каменные мотыги из Днепровского Надпорожья при помощи петрографического анализа в шлифах. Впервые проведено сравнение сырья каменных мотыг с горными породами района на основании микроскопического изучения.

Практическая значимость. Полученные данные могут быть использованы при реконструкции истории зарождения горного дела на территории Среднего Приднепровья.

Ключевые слова: *древнее горное дело, неолит, Днепровское Надпорожье, гранитоиды, каменные мотыги*

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